X-ray Holographic Microscopy with Total-reflection-mirror Interferometer

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Holographic microscopy with a wavefront-dividing-interferometer has been developed. The concept of optical system is the same as that of electron holographic microscopy. A magnified image of object is generated at an image plane of objective lens, and a refractive prism (or a total-reflection plane mirror) is placed behind the back-focal-plane of objective lens to configure the wave-front-dividing interferometer, as shown in the figure. A half of divergent wave from the focal point is deflected by the total-reflection mirror, and superimposed on the magnified image of object. The interferometer with total reflection mirror is an analogue of Lloyd's mirror interferometer that is well known in the visible light optics.

We have already reported holographic microscopy with Fresnel zone plate objective and refractive prism interferometer [1]. Here, we will present hard X-ray holographic microscope with total-reflection-mirror interferometer, and quantitative phase measurement will also be shown.

A coherent illumination over the acceptance of objective lens is needed for holographic microscopy. The coherent illumination is achieved at BL20XU of SPring-8 by using the undulator light source and the long beamline (experimental station located at 248 m from source points). X-ray energy of 12.4 keV is chosen with a Si 111 double crystal monochromator. A Fresnel zone plate made of 1 μm-hick tantalum is used as an objective lens. The focal length is 155 mm at 12.4 keV, and the outermost zone width is 100 nm. The total reflection mirror is a conventional plane mirror made of borosilicate crown glass (figure error of about 30 nm).

The required spatial coherence for the imaging holography is only one-dimensional coherence, while the two-dimensional coherence is needed for projection-type holography. Asymmetric coherent property of synchrotron radiation light source, i.e. high spatial coherence in the vertical direction and low coherence in the horizontal direction, is used to suppress the speckle noises [2].

Phase retrieval has been performed using two methods: fringe scanning algorism and Fourier transform method. Typical result of phase retrieval by 4-step fringe scan is shown in the figure. The sample is latex sphere with a diameter of 8 μm.

1. Y. Suzuki and A. Takeuchi, Rev. Sci. Instrum. **76** (2005) 093702.
2. Y. Suzuki and A. Takeuchi, proceedings of SRI2006, in press.